# CHAPTER 1: INTRODUCTION

## Background

Growing public awareness that areas such as the Love Canal neighborhood in New York, the "Valley of the Drums" in Kentucky, the Stringfellow Acid Pits in California, and other sites across the nation were contaminated with hazardous substances, much of it industrial waste, sparked a national controversy in the 1970s. Dramatic events, like the 1978 fire at an illegal hazardous waste site in Chester, Pennsylvania that hospitalized over forty firefighters, only added to the sense of urgency (Wildavsky 1995). The ensuing debate over how best to deal with these problems led to the creation of the Superfund program under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, and the Superfund Amendments and Reauthorization Act (SARA) in 1986. Together, these and related laws established a federal program for preventing, mitigating, and responding to releases of hazardous substances that might threaten human health and the environment. The term "Superfund" in this chapter will refer to this entire system of laws, regulations, and activities.

Superfund has many areas of accomplishment. It established a federal trust fund to pay for response to releases and other costs of implementing the statutes, and complementary liability mechanisms to recover these costs from the polluters. It led to support for communities that were burdened with hazardous material sites so they could better understand and participate in decisions about what to do with them. Superfund created a program for developing and deploying knowledge and technologies to better manage hazardous substances. It provided training for thousands of first responders (fire fighters, police, emergency room nurses, etc.) so they could detect and identify hazardous substances in order to protect themselves and the public. It has enabled the restoration of hundreds of communities and ecosystems. Finally, Superfund created a powerful incentive for innovation to reduce the need for hazardous substances in the economy and the amount of hazardous waste that is generated.

Through these efforts, the Superfund program has led to many benefits. These include reduced human health risks for cancer, lead poisoning, acute injuries involving hazardous substances, and probably birth defects. These benefits also include improved environmental quality at thousands of sites across the country, and the protection of a substantial portion of the nation's groundwater. CERCLA, SARA, and related laws have also increased knowledge about and capability to deal with accidents involving hazardous substances through research, development, and training. Recently, these capabilities have proven useful in counter-terrorism planning and response.

Contamination with hazardous substances is a massive problem. Over the last 24 years, the U.S. Environmental Protection Agency (EPA) has responded thousands of times under the authority of Superfund legislation (CERCLA and SARA) to deal with the problem of hazardous substances in the environment, and Superfund continues to respond to over 300 new (or newly discovered) releases every year. These actions have halted the exposure or potential exposure of millions of people to hazardous substances and permanently destroyed or isolated many tons more. R. N. Andrews referred to CERCLA, SARA, and related laws in the history of American environmental policy, describing that "the transformation of waste management practices was

one of the most impressive yet least noted successes of American environmental policy" (1999, 249).

This study, the Superfund Benefits Analysis (SBA), has four objectives: to *enumerate* the benefits of the Superfund program, to *describe* each one, to *quantify* those benefits for which the appropriate data are available, and to *monetize* benefits when possible. It is a retrospective study, covering the benefits resulting from activities during the period 1980–2004. It looks at a wide array of programs and policies, as discussed below. Although this study is not, strictly speaking, a regulatory analysis, it follows the spirit and intent of guidance for regulatory analysis as closely as possible, such as EPA's *Guidelines for Preparing Economic Analyses* (EPA's *Guidelines*) and the Office of Management and Budget's *Circular A-4* (U.S. Environmental Protection Agency 2000, Office of Management and Budget 2003).

Original research was conducted for the current study. In addition, the current study summarizes and utilizes the large body of previous research on Superfund and related issues. This literature includes peer-reviewed papers, government reports, and prior external analyses of the program (e.g., Office of Technology Assessment 1989; Hird 1994; Probst and Konisky 2001; Hamilton and Viscusi 1999a) for concepts, methods, and data.[1] Notably, this study employs benefits transfer, which is a method that relies strongly on previous research (Rosenberger and Loomis 2003).

This study attempts to identify as comprehensively as possible the full range of Superfund benefits. Most public debate about and prior research on the Superfund program has focused almost exclusively on the NPL program, for reasons discussed in Chapter 2 (exceptions include pp. 153 and 186 of Wildavsky 1995; Chapter 3 of Probst and Konisky 2001; and Anderson, Thompson, and Suk 2002). An important outcome of this focus is that there are more data available about the NPL than on other parts of Superfund. Although EPA makes data available in multiple ways that are suitable for many groups (see Appendix A), gaps in the available data have limited the amount of quantification and monetization possible for benefits associated with non-NPL parts of Superfund. Nonetheless, by at least enumerating and describing these other benefits, the current study will improve the understanding of the value of the Superfund program. However, as a result of these gaps, the quantitative estimates of the benefits of the Superfund program presented in this study are likely to be biased downward, perhaps significantly.

Because numerous programs and activities are created by Superfund, it is helpful to use the term "approaches" as discussed in Chapter 4 of *EPA's Guidelines* . In this study, six basic approaches taken under Superfund are defined, as well as nine categories of benefits, as shown in Figure 1.1. These approaches are a useful way to conceptualize what the Superfund program does and are defined later in this chapter. However, these approaches do not necessarily match the programmatic elements of the Superfund Program (e.g., remedial investigation/feasibility study, remedial design, public health assessments by ATSDR, etc.). In most cases, more than one

[1] The book *Calculating Risks?* (Hamilton and Viscusi 1999a) contains research that also appeared in peer-reviewed journals (see p. xi of that volume), and for convenience the book will be referred to instead of the journal articles (e.g. Hamilton and Viscusi 1995; Viscusi, Hamilton, and Dockins 1997; Hamilton and Viscusi 1999b; Viscusi and Hamilton 1999; Gayer, Hamilton, and Viscusi 2000; Gayer 2000).

program or activity is included in each approach, while individual programmatic elements can be described as taking one or more approaches.

Figure 1.1 shows nine benefit categories, divided into "Fundamental" and "Embedded" categories. The fundamental benefit categories are those found in the EPA's *Guidelines for Conducting Economic Analyses* (Exhibit 7-1, p. 67) and are the most basic reasons for the Superfund program: to mitigate human and ecological health risks, to improve other amenities, and to reverse environmental damage to materials.[2] In many cases, these benefits are generated directly. However, there are other important outcomes of the Superfund program that are labeled embedded because they are direct objectives of the Superfund program and would likely be ignored if only the Fundamental benefit categories were considered. Of course, the embedded benefit categories are valued largely because they lead *in*directly to the fundamental benefits (or to lower costs). However, it is not possible to quantify any future fundamental benefits, so the distinction between fundamental and embedded benefit categories is a response to the difficulty in measurement. In the current study, only fundamental benefits are quantified, so no issue of double counting arises.

**Figure 1.1. Approaches Taken Under Superfund and Resulting Benefit Categories**

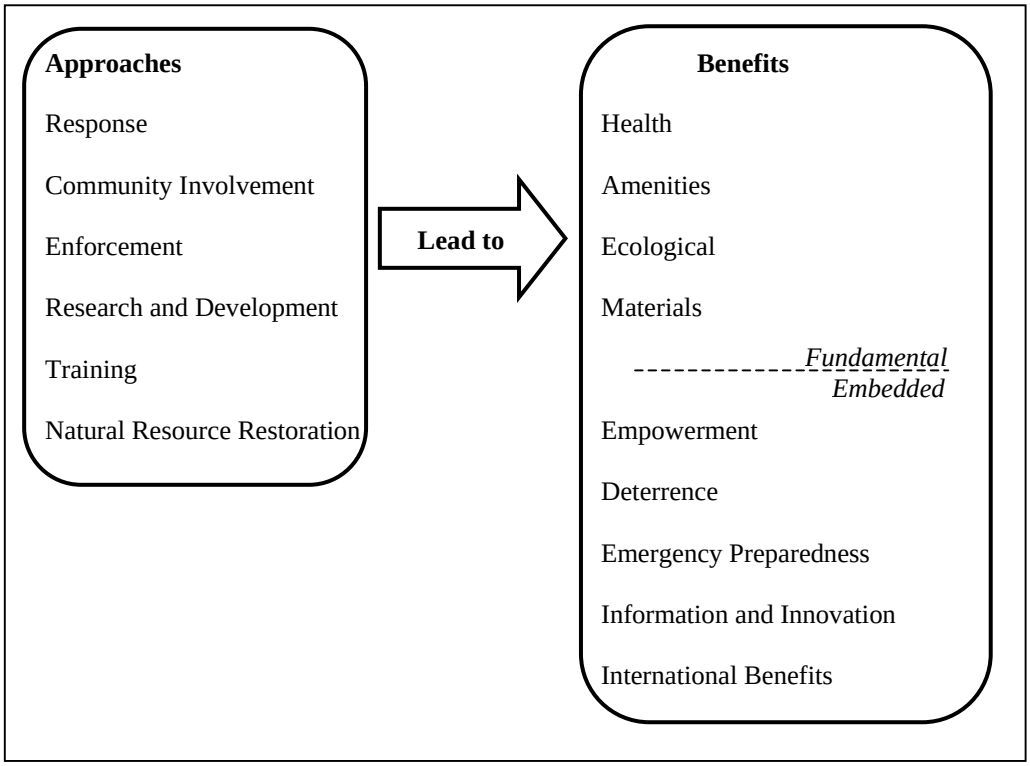



Figure 1.1 also shows the essential relationship between approaches and benefits. There are few one-to-one relationships between approaches and benefits. In general, several of the approaches contribute to each benefit category. The current study focuses on the benefits, shown on the right, but also describes the approaches where appropriate.

[2] The names of the fundamental benefit categories have been changed slightly for clarity.

The best known part of Superfund is the work to find remedies to actual or potential releases of hazardous substances (or, simply, "releases") at sites on the National Priorities List (NPL). These are part of the "Response" approach shown in Figure 1.1. Often, remedial action involves removal or destruction of the hazardous substances, but sometimes it involves containing them for the long-term in specially engineered systems. The NPL was originally created as a list of the worst hazardous substance sites in the country, but in the last decade many of the most serious problems have come to be addressed by state programs, often overseeing private remedial actions, and the NPL has become a tool for addressing the subset of worst sites at which federal resources are needed (e.g., abandoned sites), or at which federal enforcement powers are needed.

The remainder of this chapter addresses issues identified in pp. 5-17 of EPA's *Guidelines for Preparing Economic Analyses*, as applicable to a retrospective analysis, in order to provide a framework for understanding the SBA.

**Problem Definition**

The Superfund program addresses the problem of actual or potential uncontrolled releases of hazardous substances into the environment.[3] By the time CERCLA was passed in 1980, improvement of hazardous waste management in the United States was already under way following the passage of the Toxic Substances Control Act (TSCA) and the Resource Conservation and Recovery Act (RCRA) in 1976. These laws governed the active production and controlled release (such as landfill disposal) of hazardous substances. However, there was growing evidence that substantial quantities of uncontrolled hazardous substances existed in places and in conditions throughout the United States that could present human health and ecological risks, or might reasonably be expected to do so in the future. These hazardous substances were the result of *prior* actions, which neither TSCA nor RCRA had addressed directly. Moreover, it was clear that many sites with hazardous substances at them had *potential* uncontrolled releases that had not yet leaked or spilled. Lastly, it was clear that accidents and illegal activities also created new uncontrolled releases (Landy, Roberts, and Thomas 1994, ch. 5).

Since the passage of CERCLA, many previously hidden instances of contamination have been discovered and new releases of hazardous substances have continued to occur. Most of these contaminations are located at either current or former industrial sites or waste disposal sites, but some are at military bases and facilities associated with nuclear weapons production. The Superfund program deals with places where releases have both occurred due to deliberate actions (sites) as well as those due to accidental actions (spills).

[3] Although it is common to use the terms 'hazardous substance,' 'hazardous material,' and 'hazardous waste' interchangeably, these terms have different statutory definitions. CERCLA and SARA authorize EPA to address hazardous substances, including wastes as well as other types of substances (e.g., product spills), but *excluding* petroleum and petroleum products. Oil spills are dealt with under the Oil Pollution Act by agencies authorized to address hazardous *materials*. The management of hazardous wastes, including the treatment, storage, and disposal of hazardous wastes, is regulated by the Resource Conservation and Recovery Act. CERCLA and SARA deal with *uncontrolled* releases of hazardous substances, both wastes and non-wastes.

It is important to place the concepts of *toxic*, *hazard,* and *risk* into perspective (Paustenbach 2002). Toxicity is an inherent property of all substances; that is, any chemical can cause adverse effects in sufficient concentrations (i.e., "the dose makes the poison"). In contrast, hazards are specific situations that raise the likelihood or severity of an adverse outcome, such as exposure to a substance at concentrations that could lead to an adverse effect. The term risk is used to refer to the probability (or likelihood) that an adverse health outcome will occur in a person or group exposed to a specific concentration of a hazardous agent. For ecological systems, risks are the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. Typically, risks associated with uncontrolled releases of hazardous substances are the result of a completed exposure pathway (CEP) linking the release with sensitive receptors (i.e., people or wildlife).

The principal inherent dangers presented by hazardous substances are negative health effects, including both acute effects (e.g., acute poisoning, injuries from fires or explosions) and a variety of long-term effects (e.g., cancers, birth defects) (Johnson 1999; Bove, Shim, and Zeitz 2002; Dolk and Vrijheid 2003). Hazardous substances found at Superfund sites that cause such effects include: lead, arsenic, benzene, trichloroethylene, and mercury, and over 250 other hazardous substances (Agency for Toxic Substances and Disease Registry 2003). In addition, the Superfund program sometimes deals with substances that are explosive or radioactive (Probst and Konisky 2001, 20; Johnson 1999, 85).

In order for a hazardous substance to present a health risk, a pathway for exposure to that substance must exist. A completed exposure pathway occurs when five elements are present: a source of contamination, an environmental media and transport mechanism, a route of exposure, a point of exposure, and a receptor population (for a general discussion of this issue, see Williams and Paustenbach 2002.) Since 1990, completed exposure pathways for hazardous substances have been found at over 15,000 sites (NPL and non-NPL) in the United States (Agency for Toxic Substances and Disease Registry 2003). Exposure to hazardous substances varies significantly from site to site, and human exposure to hazardous substances may occur through multiple routes. Data on human exposure due to uncontrolled releases of hazardous substances exist for some cases but no collection of exposure data useful for an overall analysis of expected risk is available.[4] Research based on site-specific investigations at NPL sites suggests that the most important exposure medium is ground water, followed by soil, air, biota, and other media, and that ingestion is by far the most important exposure pathway, followed by dermal contact and inhalation (Hamilton and Viscusi 1999a, 24-57). Nonetheless, the lack of definitive exposure data frustrates this area of research (Harrison 2003).

Uncontrolled releases of hazardous substances can also damage ecological systems that provide services to both humans and other species. Examples of ecological risks include contamination of ground water, wetlands, lakes and rivers, estuaries, and grasslands (Jones, et al. 1999; Morey et al. 2002). This contamination can reduce organism survival and growth rates, change species

[4] Specifically, exposure and risk information for the maximally exposed individual (MEI) exists for most sites on the National Priorities List (NPL), but these data are contained in individual baseline risk assessments for each site and are not compiled in a single place, so are not readily accessible. Further, neither data for typical individuals nor population exposure data exist for these sites, and even less information is available for non-NPL sites with uncontrolled releases of hazardous substances, which are far greater in number (see Chapter 2).

composition, reduce ecosystem productivity, and have other effects which can lead to reductions in valued ecosystem services such as water filtration, nutrient cycling, fishing, and use of habitat.

Without the intervention of Superfund, the magnitude of such effects likely would have worsened over time, as more and more containers and facilities holding hazardous substances failed, as leaked substances spread through ground water, and as more people came to live near or even on such sites.

It is important to recognize that a crucial part of the hazardous substances problem in 1980 was that very little was known about the nature or extent of the problem. While there were indications that hazardous substances had contaminated many places throughout the country, and it was known that some of these substances had physiological effects, there was a great deal of uncertainty as to the number of such problems and the nature and magnitude of the associated risks to human health and the environment. There was also very little knowledge about how best to remediate contaminated sites. This lack of knowledge is unsurprising, given the laws and incentives up to 1980; there was no reason for private industry to invest in these scientific and engineering questions, and before the existence of a public policy problem was identified, little reason for government to sponsor such research (Norberg-Bohm 1999; Jaffe, Newell and Stavins 2002). However, this lack of knowledge created uncertainty and concern among the public about the potential impacts of hazardous substance releases on the health and well-being of their families. The Superfund program has greatly reduced the uncertainty associated with the problem of uncontrolled releases of hazardous substances and provided much better tools to manage the problem.

As part of the Federal Government, the Superfund Program is subject to Executive Orders, which in some cases mandate EPA and other agencies to pursue objectives that may have beneficial effects that are not included in either the fundamental or embedded categories. For instance, Executive Order 12898 requires federal agencies to identify and address, as appropriate, "disproportionately high and adverse human health or environmental effects … on minority populations and low-income populations" (President of the United States 1994). Executive Order 13132 requires consultation with affected state and local governments on rules that have "substantial direct effects on the States [and local governments] … or on the distribution of power and responsibilities among the various levels of government" (President of the United States 1999). Executive Order 13175 recognizes the unique legal relationship between the United States and Indian tribal governments as set forth in the Constitution, treaties, and other documents. It seeks to establish regular and meaningful consultation and collaboration with Indian tribal governments (President of the United States 2000). To the degree that the Superfund program achieves these goals, it can be said to be creating beneficial effects.

**Reasons for Market Failure and the Need for Federal Action**

Beginning in the nineteenth century, modern science and industry introduced compounds into the environment not found in nature, but useful for their new properties, such as persistence and ability to control pests. Unfortunately, these same properties make these materials potential hazardous contaminants. As industrial processes in the United States grew in size and began to use greater amounts of hazardous substances, contemporary waste management practices (described as "cheap and casual" in Andrews 1999, 245) were applied to hazardous materials as

well. However, the effects of hazardous substances could be very different from those of traditional wastes, for which odor and infectious disease were the principal problems, so these practices resulted in significant potential exposures of humans and the environment to hazardous chemicals (Hays 1987, ch. 6). This situation began to change in 1976, when the Resource Conservation and Recovery Act (RCRA) was passed, but in the meanwhile the combination of lack of awareness of the attendant risks of hazardous wastes and little concern about these risks resulted in a sufficient number of abandoned hazardous waste sites that the public and Congress determined that federal action was needed (Hird 1994).

Problems of poor risk management fall into the category of *externalities*. Externalities are effects that are created by economic activity (e.g., manufacturing) but are not included in the decision-making about or the cost assigned to that activity. Manufacturers who produced hazardous wastes could legally dispose of these wastes without significant concern about future risks. Manufacturers could store wastes at their facilities, which they could readily abandon if the wastes became problematic without any sense of stewardship for the hazardous wastes. Waste storage and disposal facilities were also not required to consider potential risks. Government action is usually required to correct externalities (Baumol and Oates 1988).

An additional problem is the lack of incentives for discovery and innovation that are aimed at providing public goods, such as environmental quality (Orr 1976; Baumol and Oates 1988; Jung, Krutilla, and Boyd 1996). Public goods are products or services that if supplied to one person are available to others at no extra cost. Generally, public goods are considered non-rival in that consumption by one person does not reduce the amount available to others, and are considered non-excludable in that the producer is unable to prevent anyone from consuming it. For these reasons, markets in public goods rarely exist, which is why there are few incentives for discovery and innovation that are aimed at producing the public goods. Thus, there may be no market demand whatsoever for environmental information. In this case, private firms tend to find it uneconomic to invest in research and development to provide either information or technologies (Taylor, Rubin, and Hounshell 2003). For the case of sites contaminated with hazardous substances, the cost of remedial action is generally not justified by increased returns in real estate markets. Thus, government action is required to both learn about and remedy contaminated properties.

**Defining Superfund Approaches**

CERCLA and the various Superfund programs address the problem of uncontrolled releases of hazardous substances using a wide range of approaches. The federal government implements many of these approaches. CERCLA and SARA are the authority for all of the federal actions, and they provide strong support for many state and private actions. The federal government also provides significant budgetary support for state environmental programs. Hence, the state and private actions can be partially attributed to the federal statutes. Together, federal, state, and private industries take actions under Superfund, which can be classified into six basic approaches, as shown in Figure 1.1 and defined in Table 1.1.

**Table 1.1. Superfund Approaches**

| Name | Description |
|---|---|
| Response | Remedial Activities: Activities associated with sites (including the NPL, non-NPL federal sites, state sites, private sites) and spills to reduce the amount, toxicity, and mobility of hazardous substances in order to reduce human health and ecological risks. As used here, "cleanup" includes institutional controls designed to prevent exposure. Remedial actions tend to address only actual releases, but may address potential releases as well. |
| | Removals: Activities designed to address immediate human health risks due to uncontrolled releases of hazardous substances. Removals may occur at all types of sites and spills, and may be taken by federal or state agencies. Emergency responses include actions taken following terrorist attacks. Removal actions may address either potential or actual releases, and account for most of the potential releases addressed by response actions. |
| Community Involvement | Activities that assist citizens and businesses located near sites undergoing cleanup to better understand and participate in the process. |
| Enforcement | Actions taken by federal and state governments to effect response actions by potentially responsible parties, to recover costs of federal and state responses, and to restore natural resources. |
| Research and Development | Efforts to better understand hazardous substances and their effects on human health and the environment, to develop new technologies and strategies for reducing the risks of hazardous substances, and to lower the cost of cleanup. |
| Training | Activities designed to improve the capability of professionals (e.g. paramedics and firemen) and organizations (e.g. hospitals and municipal governments) that may be required to address releases of hazardous substances, often state and local first responders and first receivers (i.e., hospital emergency departments). Includes homeland security preparedness. |
| Natural Resource Restoration | Actions taken to return ecological features (rivers, prairie, scenic vistas) back to conditions similar to those before hazardous substances were introduced and thus restore the flow of valued services (e.g., fishing, Tribal uses, wildlife habitat, protection of resources for future generations). |

Response is the most direct and obvious of the approaches taken under the Superfund program, and by far the most expensive, accounting for perhaps as much as 90 percent of all resources (public and private) expended under CERCLA and SARA.[5] Superfund is not really a regulatory approach, but encompasses a broad set of activities that can be grouped into two sets, based largely on size and underlying legal authority. Superfund responses are designed to address the continuum of health and environmental risks ranging from emergencies to long-term problems. Technical options include containment, chemical neutralization, biodegradation, incineration, ground water treatment, institutional controls (e.g., temporary access control by fencing or permanent restrictions on activities such as digging), and others. Statutory authority for removal actions, and in particular time-critical removals, provides for rapid response where the problem needs to be addressed in an urgent manner. Time-critical removals are conducted without the level of administrative and planning activities needed to support remedial actions. They are typically used to respond to chemical spills, human health threats that might cause harm from short-term exposures (e.g., lead-contaminated residential soils), and situations that may cause a sudden release (e.g., leaking drums). Remedial actions and some removal actions (non-time

[5] This value is calculated by adding EPA's expenses that are directly related to response (~$1 billion annually), to Department of Energy, Department of Defense, state, and private expenditures (>$4 billion annually), assuming the latter four all go to response, and dividing this by the sum of all Superfund-related expenditures (~$5.5 billion annually) (Probst et al. 1995, 111; Probst and Konisky 2001, 9-12).

critical removals) address situations where the response can be taken in a more deliberate fashion, allowing for more in-depth planning and evaluation. Remedial actions are limited by regulation to sites on the NPL.

However, the distinction between remedial actions and removals is not as sharp as it might seem. The types of response actions that can be taken (e.g., waste treatment, excavation and disposal, providing alternate water supplies) are identical under both sets of authorities, except that permanent relocation of residents is only specifically authorized as a remedial action. In practice, the removal program is often used to address completed exposure pathways with higher levels of exposure, while the remedial program addresses risks where there are no current exposures or where the levels of exposure allow for a more deliberate planning process.

State agencies and private firms also respond to potential or actual releases of hazardous substances. The benefits of these responses are partially attributable to Superfund due to funding and technical assistance provided to states, the ability to use (or at least threaten to use) CERCLA's liability provisions, and the availability of information and technological innovations created by the Superfund program. Many, but not all, of these state and private responses are smaller and simpler than those handled by the federal government (Probst and Konisky 2001, 93-97). Further, state hazardous substance cleanup programs rely heavily on the federal Superfund program in a number of ways. The federal Superfund program has created the knowledge, technology, and skills needed to assess the risks of hazardous substance sites and clean them up safely. In addition, the existence of the Superfund law, with its very significant liability provisions, supports state programs, which can use the threat of federal enforcement actions to elicit cooperation from private firms. Moreover, under the Core State and Tribal Cooperative Agreements, the federal Superfund program has invested over $300 million to build and maintain state capabilities (see also Chapter 3).

The second approach includes efforts to improve the involvement of communities near remedial action sites. These efforts help individuals, families, and communities understand sites near them, and participate in Agency decisions about those sites. One example is the Technical Assistance Grant (TAG), which is described in Chapter 6 of the current study.

The third approach includes enforcement efforts, which have brought far more resources to bear on the problem of releases than the federal government had available. This has led to many more response actions and the cleanup of many more contaminated sites. In addition, enforcement activities help ensure that the parties responsible for the contamination problem pay the costs of cleaning it up. That is, enforcement helps make certain that the "polluters pay" as much as possible. Much of the authority for enforcement derives from the stringent liability provisions of Superfund, along with the enforcement provisions. These provisions are also powerful incentives for private innovation in products and processes that need fewer hazardous substances as inputs and produce less hazardous waste, although RCRA and other laws also contribute to this effect. These provisions also serve as a backstop to state response programs and help encourage private firms to respond to releases on their own.

The fourth approach to address the problem of uncontrolled releases of hazardous substances is research and development, which are conducted by EPA's Office of Research and Development

(ORD) and Environmental Response Team (ERT), the Agency for Toxic Substances and Disease Registry (ATSDR), and the National Institutes of Environmental Health Sciences through the Superfund Basic Research Program (SBRP). These organizations also engage the fifth approach, the training for a variety of groups, including first responders (e.g., firefighters), first receivers (i.e., emergency room staff), and scientists. While there are still limitations in the understanding of hazardous material risks and in the methods and technologies for managing releases, these research and training efforts have gone a long way toward improving our scientific knowledge and practical capabilities since 1980.

The fifth approach, called training, involves efforts to make professionals in many different fields more capable of identifying and responding safely to uncontrolled releases of hazardous substances. It differs from the empowerment approach in that it is focused on professionals and relevant organizations like hospitals and municipal governments, not the public. Many different Superfund-supported organizations conduct training in this sense, including especially OSRETI , the Environmental Response Team (ERT), and ATSDR. These activities include training to deal with some types of homeland security issues, for instance attacks with biological agents.

The sixth response-related approach is natural resource restoration,[6] which frequently occurs at NPL sites, but which can also occur at accidental spills. These efforts are aimed mainly at restoring ecological functions that have been damaged or destroyed by uncontrolled releases of hazardous materials. Natural resource restoration has become an increasingly important approach taken under Superfund in the last decade. Natural resource restoration activities are undertaken by organizations that act as public trustees, including several federal departments (e.g. Commerce and Interior), states, and tribes, but not EPA. This approach is included in this discussion for completeness, and the analysis of natural resource restoration in Chapter 5 is included because it is the only approach available to quantify and monetize ecological benefits associated with the Superfund program.

**Defining Superfund Benefits**

In this section, the types of benefits created by the Superfund program are briefly described, as are the methods used in the remainder of the study to quantify and monetize them. Subsequent sections of this study that discuss these benefits are identified.

The framework described in section 7.4 of EPA's *Guidelines for Preparing Economic Analyses* identifies four benefit categories: human health, amenities, ecological/agricultural, and materials. In this study, these four are labeled as fundamental benefits because they are the basic reasons for the Superfund program and are the benefits linked in economic theory to improvements in welfare. The Superfund program creates benefits in all four of these benefit categories, as defined in Table 1.2.

[6] Executive Order 12316 (46 FR 42237) delegated the Presidential authorities of CERCLA to various federal agencies. While EPA is charged with implementing most of the response provisions of CERCLA and many of the enforcement provisions, the natural resource damages provisions of trustees are assigned to the various federal agencies (e.g., the Departments of Agriculture, Commerce, and Interior). CERCLA also authorizes states to act as trustees. Hence, for the purpose of conducting a comprehensive evaluation of Superfund benefits, this study is not limited to those programs implemented by EPA.

However, there are real but unmeasurable benefits of the Superfund program, labeled as embedded. These embedded benefit categories are valued largely because the lead *in*directly to the fundamental benefits (or to lower costs). However, it is not possible to quantify any future fundamental benefits, so the distinction between fundamental and embedded benefit categories is a means of identifying important outcomes that might be ignored if only the direct, fundamental benefits were considered. Another way of making this distinction might be to think of the fundamental benefits as direct, and the embedded benefits as describing routes by which the fundamental benefits may be indirectly achieved.

In Chapters 3, 4, and 5, only the fundamental benefits are quantified and monetized. The embedded benefit categories are not. The only exception to this statement is for the property-value based estimate in Chapter 4. As described in that chapter, it is not possible to know exactly what benefit categories are being measured.

**Table 1.2. Brief Definitions of Benefit Categories**

| Benefit | Definition |
|---|---|
| *Fundamental* | |
| Health | Actions taken to improve human health, which may include reducing the magnitude of exposure to contaminants, reducing the number of exposure pathways, reducing the length of exposure, and providing information so that individuals can reduce their exposure or seek medical treatment. |
| Amenities | Any feature of a place, object, or experience that enhances its attractiveness and increases the user's satisfaction, but is not essential to the place, object, or experience. In the context of Superfund, amenities include the removal of unsightly structures, the reuse of abandoned property, the avoidance of the stigma associated with contamination, and the reduction of perceived health risk from uncontrolled releases of hazardous substances. |
| Ecological | The restoration and maintenance of service flows to both humans and nature from natural resources, such as land, ground water, and habitat. These services may include recreation, clean water, shelter, food, timber, and others. |
| Materials | The reduction of risk and perceived risk associated with non-residential (i.e., commercial and industrial) properties, and the ensuing ability and willingness of the business and financial community to use these properties. |
| *Embedded* | |
| Empowerment | The ability of people who live near Superfund sites (especially NPL sites) to learn about the site(s) of interest, have questions about the site(s) answered, participate in decision-making associated with the site(s), and hold the relevant organizations accountable. |
| Deterrence | Incentives for firms and individuals that may create or use hazardous substances to handle and dispose of them properly and to avoid uncontrolled releases to the environment. |
| Emergency Preparedness | The knowledge, skills, organization, and technologies necessary to limit harm to human health and the environment following disasters involving the release of hazardous substances. Includes preparation for natural disasters, homeland security measures, and similar activities. |
| Information and Innovation | Increases in knowledge and technical capabilities created as a result of research, development, and deployment supported by the Superfund program. This includes both basic scientific research as well as efforts to develop and build experience and confidence in new technologies. |
| International Benefits | Any benefits from any of the other benefit categories that accrue to people or organizations outside of the United States. These benefits are generally coordinated with the State Department and often involve overseas response actions or training. |

In the *health* category, the Superfund program prevents potential releases, interrupts exposure pathways, and destroys or isolates hazardous substances, reducing both morbidity and mortality risk. Potential negative effects that are prevented include health endpoints such as acute effects (e.g., explosions or poisoning), cancer, and long-term non-cancer effects (e.g., increased birth defect rates). These benefits can be described as reductions in actual health risks. Some aspects of health benefits are discussed in the literature review in Chapter 2; others are discussed in Chapter 5.

The *amenities* benefit category is associated with the removal of unsightly facilities, often abandoned, as well as the psychological benefits associated with reducing the uncertainty and fear of unknown risks that might exist at nearby hazardous substance facilities. Direct amenities include improvements in aesthetic attributes associated with environmental commodities. This includes improvements in taste, odor, appearance, or visibility. In short, these benefits are determined by how the senses are affected and how an individual's welfare is changed as a result. This class of benefits is unique in that the focus is on the sensory experience and not on a physical or material effect. Despite this conceptual distinction, aesthetic benefits are often intertwined with other benefit categories, such as health and recreation. A policy that improves air quality, for example, might simultaneously improve visibility and reduce mortality risks associated with airborne contaminants. New treatments for drinking water might reduce health risks as well as alter the taste and odor of tap water. These relationships may make it extremely difficult to separately quantify and value improvements in aesthetic qualities. Many types of policies can be expected to have some impact on these kinds of amenities, and they may be the focus of a given policy. Chapter 6 of the current study discusses benefits in the amenities category.

Another part of the *amenities* benefit category is reduced uncertainty about the nature and extent of actual health risks associated with releases. By providing information about sites where releases of hazardous substances have occurred and by implementing remedies at these sites, the Superfund program also reduces perceived health risks. Even in cases where there may be little health risk, psychometric research has shown that individuals can experience genuine discomfort and anxiety if exposed to risks that are dreadful, imposed by others, out of their control, hard to understand, or have other features that hazardous substance sites are likely to have (Slovic, Fischhoff, and Lichtenstein 1979; Slovic 1987). These effects can lead to larger, more permanent damages, sometimes called stigma (Gregory, Flynn, and Slovic 1995; Satterfield et al. 2001). These issues are discussed in Chapters 2, 4, and 6 of the current study.

Benefits of Superfund in the *ecological* category come about through the restoration, or enhanced recovery, of natural resources that have been damaged by uncontrolled releases of hazardous substances. These benefits include restoration of market products (e.g., commercial fishing) as well as a number of non-market ecological benefits. Some non-market benefits can be called "active uses," such as recreational fishing, while others can be called "passive uses." Passive uses include maintaining the option to use a natural resource in the future (e.g., planning to visit a nearby park or golf course), the enjoyment of knowing that natural resources are preserved for future generations (e.g., maintaining ground water quality so it can be used for

drinking in the future), and preserving ecosystem services that both humans and wildlife depend on (e.g., nutrient cycling).

In the category of benefits due to *materials restoration*, the Superfund program transforms unusable commercial and industrial properties back into productive real estate. In many cases, the avoided damage is associated with removal of both uncertainty about the presence of hazardous substances and with uncertainty about the cost of restoring the site to a usable condition. It is important to note that these benefits are related to but independent of the liability provisions of the Superfund program.

The category *empowerment* refers to situations in which citizens are knowledgeable about and involved in Superfund-related decisions that affect their communities. Empowerment permits citizens to participate meaningfully in actions associated with Superfund and to hold the Agency accountable for its decisions. This benefit category is described further in Chapter 6.

The liability provisions of CERCLA, along with information provisions such as the Toxic Chemical Release Inventory (TRI) and Emergency Planning and Community Right-To-Know Act (EPCRA) provide opportunities for the Superfund program to act as a deterrent to possible hazardous releases. In the enforcement of CERCLA's liability provisions, EPA typically seeks to identify the potentially responsible parties (PRPs), those individuals or organizations responsible for creating or contributing to a hazardous waste site. Benefits in the deterrence category are described further in Chapter 6.

*Emergency preparedness* is an important but often poorly recognized category of benefits created by the Superfund program. The Superfund program has created a significant portion of the capability of the United States to respond successfully to attacks by weapons of mass destruction. These benefits stem from the large scale of its removal program, which allows for a critical mass of resources and expertise necessary to undertake responses at nationally significant hazardous substance problems (U.S. Environmental Protection Agency 1996). These benefits are described further in Chapter 6.

Superfund benefits in the category of *information and innovation* stem from three basic efforts: basic research into the toxicology and environmental processes associated with hazardous substances in the environment; epidemiology and health impacts information associated with contaminated sites; and technology innovation and transfer associated with various cleanup methods. This benefit category is described further in Chapter 6.

The category *international benefits* refers to any benefits described by any of the previous categories that accrue to citizens of countries other than the United States. It also includes improved relations with other countries as a result of assistance with the management of hazardous substances in those countries, which is a benefit that accrues to U.S. citizens. These benefits can help support environmental, diplomatic, and security goals of the United States. They have been achieved through EPA's Office of International Activities, often in cooperation with the State Department. To achieve these benefits, Superfund staff has provided training to a number of countries in such areas as preparedness, incident response, site assessment, and chemical safety audits. These benefits are described further in Chapter 6.

**Study Question and Baseline**

This study addresses the question: *What are the benefits of the Superfund program?* For the purposes of this study, the Superfund program includes everything authorized by or attributable to CERCLA and SARA. As discussed above, this includes response actions by EPA, state agencies, and private firms, as well as activities authorized by provisions of CERCLA and SARA taken by various programs and agencies, such as ATSDR, Department of Justice, the TAG program, the SBRP, natural resource trustees, the ERT, and similar activities undertaken by state and local programs that are authorized or supported by Superfund (General Accounting Office 1996, 1999; National Research Council 1997; Johnson 2001).

A retrospective analysis such as the current effort can use reality as the baseline, which is simply the actual history of the management of uncontrolled releases of hazardous substances from 1980–2004. In order to estimate the benefits of the Superfund program, it is necessary to consider a without-Superfund scenario that assumes that no new policies relating to abandoned hazardous waste sites were established in 1980 or subsequently.[7] In this scenario, emergencies due to releases of hazardous substances might have been ignored, or handled as state and federal disasters, as occurred at Love Canal when the Federal Emergency Management Agency took charge. Moreover, this scenario assumes that the research, innovation, training, and enforcement supported by CERCLA and SARA would not have taken place. The benefits of these secondary impacts would be hard to estimate. For instance, capabilities developed with support from Superfund were crucial to recovering from the terrorist attacks in the fall of 2001, when, for example, the EPA Superfund program responded to anthrax contamination and monitored public and worker safety at the World Trade Center. In the without-Superfund scenario, the time and cost to recover from these attacks would likely have been much higher. Similarly, without the enforcement activities of Superfund, more uncontrolled releases of hazardous substances would likely have occurred, and the first responders who would have had to deal with the releases would have been less well prepared because they would not have benefited from Superfund-supported training. Such secondary benefits are only described (see Chapter 6 of the current study) because it would be speculative to attempt to quantify or monetize them.

**Methodology**

The current study addresses the benefits of the Superfund program for the period 1980-2004. All dollar values are reported in year 2000 dollars using the Consumer Price Index as calculated by the U.S. Bureau of Labor Statistics. Although this study is a retrospective evaluation, and not exactly a regulatory analysis, it was conducted as much as practicable according to the guidance relevant to regulatory analysis (U.S. Environmental Protection Agency 2000; Office of Management and Budget 1992; Office of Management and Budget 2003).

Because of the large size of the Superfund program, the diverse nature of its activities, and the lack of quantitative data available for many aspects of it, a detailed, quantitative analysis of the entire Superfund program is far beyond the scope of this study. Thus, several strategies were employed in order to achieve the study's four objectives of enumerating and describing all of the benefits, and quantifying and monetizing benefits when possible. The description given in the

[7] See pp. 2-3 of *The Benefits and Costs of the Clean Air Act* for a similar example.

current chapter of the six approaches taken by the Superfund program and the nine benefits categories it creates accomplishes the enumeration and begins to achieve the goal of description. Chapters 3, 4, and 5 provide further description of the benefits created by response actions, and also quantify and monetize some of them. Chapter 6 completes the description of the non-quantified benefits.

Recently, the Science Advisory Board made recommendations on proposals to assess the benefits of EPA programs similar to Superfund (EPA Science Advisory Board 2002). Many of these recommendations are relevant to the design of the current study. One such recommendation is to use existing data as much as possible in the estimation of benefits, but to avoid the application of conservative risk data designed for regulatory purposes. The analyses in Chapters 3, 4, and 5 reflect these and other Science Advisory Board recommendations. It is important to recognize the limitations of the current study. In general, the quantitative estimates capture only part of the benefits and have considerable uncertainty. In particular, the monetized benefits presented in Chapter 4 may underestimate the total benefits of Superfund significantly. In addition, the benefits estimated in Chapter 5 partially overlap those estimated in Chapter 4, and therefore cannot be added.

Thus, benefits transfer analysis will be needed in order to draw on published valuation studies of Superfund (or other hazardous substance) sites (U.S. Environmental Protection Agency 2000, 59-112, 85-87; Rosenberger and Loomis 2003). In a benefits transfer analysis, rather than collecting primary data, the results of existing studies are transferred to the policy being analyzed. The case for which the existing estimates exist is often called the 'study case' and the case under consideration is often called the 'policy case.' In this analysis, the study case varies depending on the benefit being considered, because various studies have looked at different benefits, while the policy case is always the same – the existing Superfund program as a whole.[8]

Because most of the direct benefits of the Superfund program are attributable to responses and most of the available data are related to Superfund response, the number and type of these activities tend to drive the results of this study. Conducting a benefits transfer analysis requires an understanding of the characteristics of the study cases (the previous work used as inputs) as well as the characteristics of the policy case (the situation being studied). Thus, Chapter 3 discusses Superfund responses in some detail.

Like many environmental policies, the Superfund program produces many different benefits that do not have a common metric for valuation. Thus, an "effect-by-effect" approach must be used to create individual values in terms of a common unit of measurement, which can then be aggregated to estimate the total benefits (U.S. Environmental Protection Agency 2000, 59, 62-65). Where possible, effect-by-effect analysis is used. However, the detailed data needed to conduct this analysis are often lacking, so another approach is also used.

[8] Various methodological issues make it necessary to consider subsets of the entire Superfund program in some cases.

One solution to the lack of detailed data for specific effects is the use of a property-based valuation[9], an indirect method for estimating benefits (Freeman 1993, 23-26; U.S. Environmental Protection Agency 2000, 77-79). This approach has the advantage of being based on observed behavior; thus it is often considered more reliable than studies that depend on people's memories or survey responses. In addition, there is a large, high-quality literature on property-based price studies from which to draw for a benefits transfer analysis. However, this approach is also limited because not all benefits may be captured. EPA's Science Advisory Board recently found that "this approach may be a relatively simple way to get obtain *[sic]* a 'ball park' or order-of-magnitude estimate of benefits … However, if this approach is followed, the review of the literature should be updated and restricted to peer-reviewed economics journals" (EPA Science Advisory Board 2002, 3, 22).

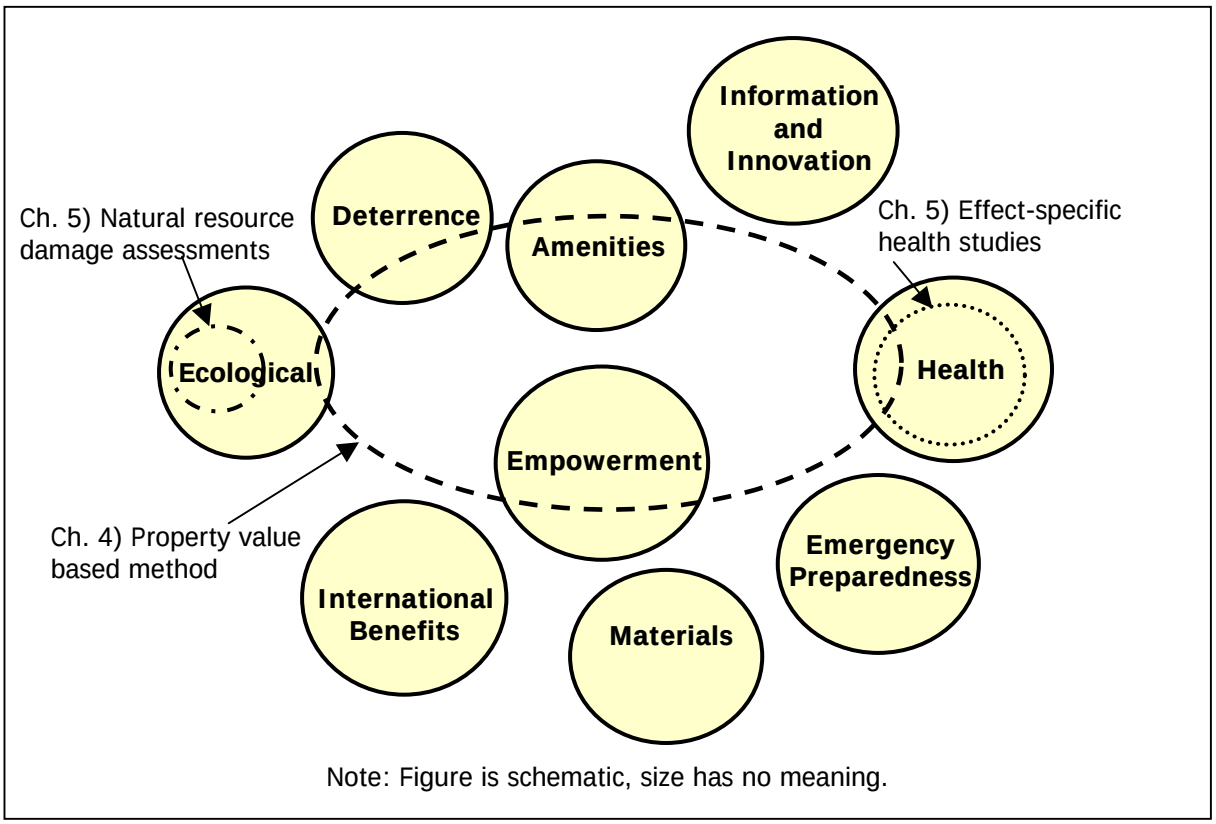
A significant disadvantage, however, is that property-based price studies do not provide information on any *specific* benefit category; any effects that are found must be interpreted as the residual effect of *all* the relevant attributes associated with the site. In addition, some benefits are not likely to be incorporated in home prices, such as bequest values that apply across an entire population. Chapter 6 of the current study contains the non-quantified benefits analysis.

Figure 1.2 illustrates the relationships between the benefits of the Superfund program and the various methods of measuring them. Each of the nine benefit categories is shown as a separate, shaded circle. (Not any of the sizes or shapes has a specific meaning). The types of benefits captured by three methods used in the SBA and by the Hamilton and Viscusi (1999b) study are shown by three types of dashed lines.

Property-based pricing studies capture all of the benefits that accrue to the consumers of the product being evaluated; here those consumers are residents close to NPL sites, labeled 'neighbors.' However, it is not possible to differentiate between the different benefits that produce this effect. Because it is based on the results of property-based pricing studies, the analysis in Chapter 4 of the current study has the same properties. Several types of benefits accrue preferentially to consumers residing near NPL sites: health, amenities (including reductions in perceived risks), deterrence (possibly due to better management of hazardous substances at facilities near their homes), empowerment, and ecological (for instance, use of parks at a remediated site near their homes). However, several benefits of the Superfund program are excluded in this type of analysis, including all those benefits that accrue to non-neighbors, such as the nonuse (or passive use) value of natural resources (e.g., rivers) that have been restored to healthy conditions.

[9] Throughout this study, "property-based valuation" and similar terms are used for simplicity to refer to analyses that rely on hedonic price theory (Taylor 2003).

**Figure 1.2 Benefits of the Superfund Program and Quantitative Estimates**




Benefits that are associated with improved conditions of natural resources (e.g., a river or wilderness area) are categorized as ecological benefits. Natural resources can also be viewed as assets that provide flows of services over time to other natural resources and to people. When natural resources are damaged, the flows of ecological and human services provided by those natural resources (and thus the values they provide) may be interrupted for some time. Restoring these service flows can create a benefit. Response actions that halt or reverse the exposure of wildlife to hazardous releases can create ecological benefits. In addition, CERCLA authorizes the federal and state governments to act as trustees for the public and seek damage claims in court against potentially responsible parties (PRPs) in order to improve the natural resource and return much of the original service flow (even if a complete restoration is not achieved). There is very limited data on potential natural resource damages, and those that exist address only damages associated with restoration activities, not responses. The Natural Resource Damage Assessments (NRDAs) associated with some of these lawsuits will capture some of these benefits, but for reasons discussed in Chapter 5, not all of them.

Ecosystems also provide services that benefit humans. For example, a freshwater lake may provide recreational and boating sites; a wetland provides a service by being a breeding ground for fish and fowl. Although ecosystems have a profound impact on human well-being, the quantitative assessment of ecological benefits presents a formidable challenge for several reasons. First, natural systems are inherently complex. The many services they provide and how

they provide them may be poorly understood, even by the scientific community. Second, ecological risks vary widely in terms of persistence (e.g., eutrophication versus species extinction), geographic extent (e.g., toxic contamination versus global climate change), and the degree to which the overall threat can be predicted (e.g., effects of ozone on crops versus developmental and behavioral effects of chemicals on wildlife populations). Third, many of the less tangible benefits are not readily amenable to monetary valuation.

**Structure of the Report**

The current study consists of seven chapters and three appendices. This introduction constitutes Chapter 1. Chapter 2 provides a general literature review. Chapter 3 provides a quantitative analysis of the number and type of Superfund responses. Chapter 4 provides an analysis that uses property value data to monetize some of the benefits of the Superfund program associated with the NPL. Chapter 5 provides a description of methods that are proposed to be used to monetize different aspects of the Superfund program, an effect-by-effect analysis of the health impacts and an analysis of ecological benefits. Chapter 6 provides a description of the non-quantified benefit categories. Chapter 7 provides a summary of the current study and identifies opportunities for future research.

Appendix A provides a list and description of data sources used. Appendix B provides a list of case studies, which are located throughout the text where the case studies illustrate an important point. Appendix C provides an alternative presentation of the results from Chapter 4 that uses 2004 as the base year for discounting instead of 1980.

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